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Timing of Changes in Three-Dimensional Spinal Parameters After Selective Thoracic Fusion in Lenke 1 Adolescent Idiopathic Scoliosis: Two-Year Follow-up

Saba Pasha, PhD[a,*], John M. Flynn, MD[a], Paul D. Sponseller, MD[b], Giuseppe Orlando, MD[c], Peter O. Newton, MD[d], Patrick J. Cahill, MD[a], Harms Study Group

[a]*Division of Orthopaedic Surgery, Children's Hospital of Philadelphia, 3401 Civic Center Blvd, Philadelphia, PA 19104, USA*
[b]*Department of Orthopaedic Surgery, Johns Hopkins University, Baltimore, MD 21218, USA*
[c]*School of Orthopedics, University of Messina, Piazza Pugliatti, 1, 98122 Messina ME, Italy*
[d]*Department of Orthopedics, Rady Children's Hospital, 3020 Children's Way, San Diego, CA 92123, USA*

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Abstract

Study Design: Retrospective analysis of the prospectively collected data.
Objective: To investigate the relationship between the axial rotation of the unfused lumbar spine and the parameters of the instrumented thoracic spine at varying time points after selective thoracic fusion (STF) in Lenke 1B and 1C adolescent idiopathic scoliosis (AIS).
Summary of Background Data: The impact of STF on the spontaneous lumbar curve correction in AIS has been studied mainly in the frontal planes. The relationship between the spontaneous transverse plane correction of the lumbar spine and the parameters of the fused thoracic spine is not well documented.
Methods: Twenty-one Lenke 1B and 1C patients who had received STF with minimum two years' follow-up were selected. Thoracic and lumbar Cobb angles, kyphosis, lordosis, and thoracic and lumbar apical vertebrae rotations were measured at preoperative, first-erect, six-month, one-year, and two-year follow-ups. The association between the lumbar apical vertebral rotation and other thoracic and lumbar variables at different time points were determined using regression analysis. The variables significantly predicting the lumbar axial rotation correction at two years were determined from the preceding follow-up visits.
Results: Kyphosis, thoracic Cobb, thoracic apical vertebral rotation, and lumbar Cobb were significantly different between the preoperative and all the postoperative follow-ups ($p < .05$). At the two-year follow-up, a decrease in thoracic rotation and lumbar Cobb and a higher residual thoracic Cobb were associated with an improved spontaneous lumbar rotation ($R^2 = 0.41$, $p < .05$). Lumbar rotation at two years was predicted from thoracic derotation and lumbar Cobb at first erect ($R^2 = 0.30$, $p < .05$).
Conclusion: Spontaneous lumbar curve rotation correction correlated to the fused and unfused spinal parameters in the three anatomic planes. The relationship between thoracic and lumbar rotation persist up to two years after STF. Thoracic derotation is an important factor determining the lumbar rotation correction at two years after STF.

Keywords: Adolescent idiopathic scoliosis; Selective thoracic fusion; Axial plane parameters; 3D spinal parameters; Predictive model

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*Corresponding author. Division of Orthopedic Surgery, The Children's Hospital of Philadelphia, 34th Street and Civic Center Boulevard, Philadelphia, PA 19104, USA. Tel.: (215) 590-1527; fax: (215) 590-1501.
E-mail address: pashas@email.chop.edu (S. Pasha).

Introduction

The three-dimensional (3D) harmonious correction of the spine in the coronal, sagittal, and axial planes is one of the main goals of adolescent idiopathic scoliosis (AIS) spinal surgery. Advancement in surgical techniques and instrumentations yielded to improved axial rotation, sagittal spinopelvic alignment, and long-term correction of spine [1-3]. All-pedicle-screw construct decreased the complication rate and need for surgical revision and permitted direct vertebral rotation in the axial plane [1,3,4]. However, the impact of such rotation on the long-term 3D correction of the fused and unfused parts of the spine is not well documented.

Selective thoracic fusion (STF) has been performed to spare motion segments and decrease the risk of degeneration in the segments caudal to the fusion [5,6]. Although good alignment without progression has been reported after STF, this is not uniformly the case [7-10]. Although the post-STF frontal and sagittal plane parameters of the spine have been evaluated extensively in previous studies [7-10], the impact of axial plane deformity correction of the fused spine on the response of the unfused lumbar spine following surgery has not been discussed. The quantification of axial plane deformity has not been possible in the upright position until recently [11-13].

By means of biplanar stereoradiography imaging (EOS Imaging, Paris, France) and images' 3D reconstruction, we sought to quantify the changes in axial rotation of the unfused lumbar spine after STF and to describe how these changes relate to other regions of the spine and other anatomic planes of spinal deformity at varying time points after surgery in each of the lumbar modifier subtypes where decision making is challenging (B and C). We proposed to determine the spinal parameters in the three anatomic planes relating to the axial rotation of the unfused lumbar at different time points after STF. We hypothesized that some aspects of surgeon-modifiable factors in the instrumented thoracic spine are predictors of long-term 3D correction of the unfused lumbar spine.

Materials and Methods

Patient population

A total of 21 patients with Lenke 1B and 1C curves who had STF with two years follow-up were analyzed retrospectively from a prospectively collected database. Inclusion criteria included biplanar radiographs at a preoperative (baseline) and four postoperative time points (first erect [FE], 6 months, one year, and two years). All patients had direct vertebral derotation maneuver as a part of their spinal surgery. The patients' lumbar flexibility was determined from the lumbar Cobb correction on their preoperative bending film.

Biplanar imaging, 3D reconstruction, and spinal measurements

The 3D reconstructions of the spine were generated in SterEOS software (EOS Imaging). The measurement reliability and reproducibility of the SterEOS in assessment of the spinal parameters in 3D has been validated and a maximum error of 1.9° was reported [11,14]. Various parameters of the spinal deformities were calculated using the 3D model of the spine to consider the axial rotation of the spine and the change therein as opposed to using the 2D projection of the spinal deformities on the radiographs [15] (Fig. 1A). Apical vertebral rotation (AVR) of the spine was determined as the angle between the line bisecting the vertebral superior endplate and the global X-axis (Fig. 1B). A total number of 7 spinal parameters, that is, sagittal balance (anterior-posterior distance between C7 and sacrum), thoracic and lumbar Cobb angles, T1–T12 Kyphosis, L1–S1 lordosis, AVRs of the thoracic and lumbar curves at preoperative, FE, six-month, one-year, and two-year postoperative visits were measured. The normalized Scoliosis Research Society–22 score were also registered at the preoperative and two-year follow-up visits.

Statistical analysis

The frontal, sagittal, and transverse plane parameters of the thoracic and lumbar spine were compared between all the visits and between the two lumbar modifier types.

A linear multivariate regression model was used to determine the association between the lumbar AVR as the dependent variable and thoracic and lumbar Cobb angles, T1–T12 kyphosis, L1–S1 lordosis, and thoracic AVR as predictors at all the five visits. Scoliosis Research Society–22 score only was considered at the preoperative and two-year regression models. Finally, lumbar AVR at two years was predicted from the thoracic and lumbar Cobb, kyphosis, lordosis, and thoracic AVR at the FE, six months and one year. All statistical analysis were performed in R (R foundation for statistical computing, Vienna, Austria) [16].